Chemical Composition of Aboriginal Peanut (*Arachis hypogaea* L.) Seeds from Peru

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Oil, protein, and ash contents, iodine value, and fatty acid and sterol compositions were studied in the seed of 29 aboriginal *Arachis hypogaea* cultivars, originating from Peru. The results showed lower protein percentage and higher concentration of oleic acid in the variety *Hypogaea* than in the other varieties (*Fastigiata*, *Aequatoriana* and *Peruviana*). β-Sitosterol was the prominent sterol in the composition of all samples.

Keywords: *Oil; protein; fatty acids; sterols; seeds; Arachis hypogaea*

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is grown worldwide in the tropics and temperate zones primarily as an oilseed crop (Bansal et al., 1993). Peanut seeds make an important contribution to the diet in many countries. They are a good source of protein, lipid, and fatty acids for human nutrition. The fatty acid composition of the endogenous fats plays an important role in determining shelf life, nutrition, and flavor of food products (Gaydou et al., 1983).

The chemical composition of peanut seeds has been studied, in particular fatty acid composition (Worthington and Hammons, 1971; Sekhon et al., 1973), protein levels (Young and Hammons, 1973), and amino acid composition (Young et al., 1973; Ahmed and Young, 1982). However, chemical studies of aboriginal peanut cultivars originating from South America have not been undertaken. These materials contain new sources of germplasm that can be used to increase the variability in the genetic base of cultivated varieties (Banks, 1976; Norden et al., 1982).

The objective of this work was to establish the chemical composition of peanut cultivar seeds from Peru.

MATERIALS AND METHODS

Plant Material. Sound and mature seeds of 29 different aboriginal peanut cultivars from Peru were provided by the INTA (Instituto Nacional de Tecnologia Agropecuaria) peanut germplasm bank of Manfredi, Córdoba, Argentina. The collection data and taxonomic classification of the cultivars included in this study are presented in Table 1.

Oil, Protein, and Ash Contents. Three samples each containing five seeds from each cultivar were examined for oil, protein, and ash content.

Extraction of Oils. Seeds were milled and extracted for 16 h with petroleum ether (boiling range 30–60 °C) in a Soxhlet apparatus. The extracted oils were dried over anhydrous sodium sulfate and the solvent removed under reduced pressure in a rotary film evaporator. Percentages of oil of these peanut meals were determined by weight difference.

Table 1. Collection Data of *A. hypogaea* Cultivars Originating from Peru

classification	cultivar[a]	RCM[b]	origin of sample
subspecies *hypogaea*			
var. Hypogaea	1 Ph	89/2479	Huallaga
	2 Ph	89/2485	Huanuco
	3 Ph	89/2487	Iquitos
	4 Ph	89/2490	San Martin
	5 Ph	89/2491	Tarapoto
	6 Ph	89/2492	Huanuco
subspecies *fastigiata*			
var. Fastigiata	7 Pf	89/2496	Lima
	8 Pf	89/2500	Tarapoto
	9 Pf	89/2505	Cuzco
	10 Pf	89/2510	San Francisco-Ayacucho
	11 Pf	89/2512	Ayacucho
	12 Pf	89/2516	Quillabamba-Cuzco
var. Aequatoriana	13 Pa	89/2520	Piura
	14 Pa	89/2521	Lima
var. Peruviana	15 Pp	89/2523	Lima
	16 Pp	89/2526	Tarapoto
	17 Pp	89/2527	Iquitos
	18 Pp	89/2530	Lima
	19 Pp	89/2538	Quillabama-Cuzco
	20 Pp	89/2542	Tarapoto
	21 Pp	89/2544	Tarapoto
	22 Pp	89/2547	Yungas
	23 Pp	89/2549	La Molina-Lima
	24 Pp	89/2556	La Molina-Lima
	25 Pp	89/2562	Yungas
	26 Pp	89/2566	Tarapoto
	27 Pp	89/2572	Ayacucho
	28 Pp	89/2580	Tarapoto
	29 Pp	89/2581	Iquitos

[a] The aboriginal cultivars are identified with a number and letters. The letters indicate the country of origin and variety: P, Peru; h, var. Hypogaea; f, var. Fastigiata; p, var. Peruviana; a, var. Aequatoriana. [b] RCM, Collection Registry Number of INTA of Manfredi, Cordoba, Argentina.

Ash was determinated by incineration in a muffle furnace at 525 °C (AOAC, 1980, Method 31.012). The nitrogen content estimated by the Kjeldahl method (AOAC, 1980, Method 2.057) was converted to protein content by using the conversion factor 5.46 (Young and Hammons, 1973).

Fatty Acid Composition. Fatty acid methyl esters were prepared by transmethylation with a 3% solution of sulfuric acid in methanol, as previously described (Jellum and Worthington, 1966). The fatty acid methyl esters of total lipids were analysed on a Shimadzu GC-R1A gas chromatograph

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Table 2. Oil, Protein, and Ash Contents and Iodine Value of *A. hypogaea* Cultivars from Peru: Mean Values (*M*) and Standard Deviations (SD) for Each Variety

cultivar	oil[a] (%)	protein[a] (%)	ash[a] (%)	iodine value	cultivar	oil[a] (%)	protein[a] (%)	ash[a] (%)	iodine value
1 Ph	49.4	26.6	2.7	104	15 Pp	48.6	28.9	2.6	109
2 Ph	47.8	26.4	2.5	108	16 Pp	48.8	31.0	2.5	110
3 Ph	48.1	25.7	2.5	107	17 Pp	49.0	30.7	2.5	107
4 Ph	47.0	26.3	2.6	98	18 Pp	49.5	30.3	2.5	105
5 Ph	49.3	26.5	2.7	103	19 Pp	48.8	31.0	2.4	106
6 Ph	50.1	27.6	2.6	103	20 Pp	49.0	30.7	2.6	110
var. Hypogaea (*M*)	48.62a[b]	26.52b	2.60a	103.8b	21 Pp	49.3	30.5	2.5	117
SD ($n = 6$)	±1.17	±0.62	±0.09	±3.54	22 Pp	49.1	30.1	2.6	112
					23 Pp	49.5	30.6	2.6	106
7 Pf	47.7	28.9	2.6	111	24 Pp	49.9	30.2	2.5	111
8 Pf	50.0	30.4	2.5	105	25 Pp	48.1	31.1	2.4	109
9 Pf	48.6	29.9	2.7	111	26 Pp	49.7	30.4	2.5	109
10 Pf	49.2	31.6	2.7	111	27 Pp	49.0	30.8	2.6	112
11 Pf	48.6	31.4	2.6	110	28 Pp	48.8	29.9	2.6	114
12 Pf	49.7	30.9	2.6	111	29 Pp	50.1	30.9	2.5	111
var. Fastigiata (*M*)	48.97a	30.52a	2.62a	109.8a	var. Peruviana (*M*)	49.21a	30.47a	2.53b	109.9a
SD ($n = 6$)	±0.84	±1.01	±0.07	±2.40	SD ($n = 15$)	±0.56	±0.56	±0.07	±3.20
13 Pa	49.7	30.6	2.4	107					
14 Pa	47.8	29.6	2.5	110					
var. Aequatoriana (*M*)	48.75	30.10	2.45	108.5					
SD ($n = 2$)	±1.34	±0.71	±0.07	±2.12					

[a] Expressed as percentages (g/100 g of seeds) on dry matter basis. [b] Means followed by the same letter within each column are not significantly different at $P = 0.05$.

Table 3. Fatty Acid Composition of *A. hypogaea* Cultivars from Peru: Mean Values (*M*) and Standard Deviations (SD) for Each Variety

	fatty acid composition (g/100 g of total fatty acids)								
cultivar	16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0	O/L[a]
1 Ph	9.3	1.7	43.6	37.4	1.4	2.3	2.7	1.6	1.16
2 Ph	9.4	1.3	44.5	39.7	1.1	1.3	1.6	1.1	1.12
3 Ph	10.6	1.4	43.4	38.9	1.2	2.6	1.4	0.5	1.11
4 Ph	11.7	2.2	46.6	32.0	1.6	2.7	2.1	0.6	1.46
5 Ph	11.5	1.7	41.9	37.0	1.9	3.3	1.8	0.8	1.13
6 Ph	9.9	1.8	43.5	36.7	1.7	2.5	2.8	0.9	1.18
var. Hypogaea (*M*)	10.40a[b]	1.68a	43.92a	36.95b	1.48a	2.45a	2.07a	0.92a	1.19b
SD ($n = 6$)	±1.04	±0.32	±1.56	±2.69	±0.31	±0.66	±0.58	±0.40	±0.13
7 Pf	11.2	1.7	36.5	45.4	1.6	1.4	1.6	0.6	0.80
8 Pf	10.9	1.9	37.5	40.2	1.9	3.4	2.7	0.9	0.93
9 Pf	10.3	2.1	36.2	45.2	1.8	1.6	2.2	0.6	0.80
10 Pf	11.4	1.6	33.6	46.5	1.6	1.7	2.8	0.8	0.72
11 Pf	10.6	2.5	35.0	45.1	1.9	1.8	2.4	0.7	0.78
12 Pf	11.2	1.3	38.3	44.6	1.4	1.4	1.2	0.6	0.86
var. Fastigiata (*M*)	10.93a	1.85a	36.18b	44.50a	1.70a	1.88a	2.15a	0.70ab	0.81a
SD ($n = 6$)	±0.42	±0.42	±1.70	±2.20	±0.20	±0.76	±0.63	±0.13	±0.06
13 Pa	10.9	1.5	35.0	43.3	2.2	2.9	3.3	0.8	0.81
14 Pa	12.0	1.3	35.4	45.5	1.6	1.4	2.1	0.7	0.78
var. Aequatoriana (*M*)	11.45	1.40	35.20	44.40	1.90	2.15	2.70	0.75	0.79
SD ($n = 2$)	±0.78	±0.14	±0.28	±1.56	±0.42	±1.06	±0.85	±0.07	±0.02
15 Pp	12.7	1.5	36.5	40.3	2.1	3.5	2.7	0.6	0.91
16 Pp	12.7	1.2	33.1	46.4	1.8	1.8	2.1	0.9	0.71
17 Pp	12.9	1.7	35.7	43.4	1.7	1.6	2.3	0.7	0.82
18 Pp	13.0	1.8	34.0	42.4	2.1	2.8	2.9	0.8	0.80
19 Pp	10.9	1.8	34.9	43.1	1.9	2.8	3.5	0.9	0.81
20 Pp	12.9	1.3	34.2	45.9	1.2	1.7	2.0	0.7	0.74
21 Pp	13.2	1.6	33.4	44.5	1.7	2.2	2.6	0.7	0.75
22 Pp	13.1	1.6	31.8	48.0	1.1	1.8	1.7	0.8	0.66
23 Pp	12.8	1.6	34.6	42.4	1.8	3.8	1.9	0.5	0.82
24 Pp	13.4	1.5	34.0	46.0	1.2	2.1	1.3	0.5	0.74
25 Pp	10.3	1.8	35.2	43.9	1.5	3.5	2.8	0.6	0.80
26 Pp	13.1	2.2	33.5	45.2	1.2	1.9	2.3	0.5	0.74
27 Pp	12.2	1.4	31.7	47.9	1.6	2.1	2.3	0.6	0.66
28 Pp	11.2	1.6	34.1	47.8	1.2	1.8	1.7	0.6	0.71
29 Pp	11.2	1.4	37.5	45.1	1.2	1.4	1.5	0.6	0.83
var. Peruviana (*M*)	12.37b	1.60a	34.28c	44.82a	1.55a	2.32a	2.24a	0.67b	0.77a
SD ($n = 15$)	±0.48	±0.24	±1.57	±2.26	±0.35	±0.76	±0.59	±0.13	±0.07

[a] O/L: Oleic to linoleic ratio. [b] Means followed by the same letter within each column are not significantly different at $P = 0.05$.

equipped with flame ionization detector (FID). AT-WAX superox II capillary column (30 m × 0.25 mm i.d.) was used. Column temperature was programmed from 180 °C (held for 10 min) to 240 °C (4 °C/min). Injector temperature was 250 °C. The carrier (nitrogen) had a flow rate of 1 mL/min. A standard fatty acid methyl ester mixture (Sigma Chemical Co.) was run to use retention times in identifying sample peaks. Fatty acid levels were estimated on the basis of peak areas of

Table 4. Sterol Composition of Oils from Peruvian *A. hypogaea* Cultivars: Mean Values (*M*) and Standard Deviations (SD) for Each Variety

	sterol composition (g/100 g of total sterols)						
cultivar	Chol[a]	Camp.	Stig	Sit.	Δ^5-aven	Δ^7-stig	Δ^7-aven
1 Ph	1.3	15.6	10.2	60.9	10.3	1.7	0.6
2 Ph	2.2	17.3	8.9	58.3	12.6	0.7	tr
3 Ph	1.8	18.0	10.4	56.9	11.4	1.5	tr
4 Ph	1.9	16.9	10.7	60.2	9.5	tr	0.8
5 Ph	2.7	15.4	9.5	60.7	9.0	2.1	0.6
6 Ph	3.0	16.0	10.1	59.5	9.1	1.6	0.7
var. Hypogaea (*M*)	2.15a[b]	16.53a	9.97a	59.42a	10.32a	1.28a	0.55a
SD ($n = 6$)	±0.62	±1.03	±0.66	±1.55	±1.43	±0.74	±0.24
7 Pf	1.5	15.7	11.0	59.5	10.7	1.6	tr
8 Pf	3.2	15.3	8.8	62.5	9.4	tr	0.8
9 Pf	1.7	18.1	9.9	58.4	9.3	2.0	0.6
10 Pf	2.6	17.0	10.1	55.9	12.4	0.8	1.2
11 Pf	2.8	15.0	10.5	57.5	12.7	0.6	0.9
12 Pf	1.9	16.8	9.7	59.9	10.6	1.1	tr
var. Fastigiata (*M*)	2.12a	16.32a	0.75a	58.95a	10.85a	1.03a	0.62a
SD ($n = 6$)	±0.51	±1.19	±0.75	±2.26	±1.44	±0.69	±0.21
13 Pa	1.5	16.3	10.4	58.6	12.3	0.9	tr
14 Pa	3.2	15.9	10.0	59.1	10.1	1.7	tr
var. Aequatoriana (*M*)	2.35	16.10	10.20	58.85	11.20	1.30	tr
SD ($n = 2$)	±1.20	±0.28	±0.28	±0.35	±1.56	±0.58	
15 Pp	1.7	16.1	8.6	60.8	10.7	1.5	0.6
16 Pp	2.8	15.3	10.9	55.2	14.0	1.3	0.5
17 Pp	2.6	17.0	8.8	60.0	10.3	0.7	0.6
18 Pp	1.6	17.8	8.7	60.1	11.2	0.6	tr
19 Pp	1.7	17.9	9.4	56.9	13.6	0.5	tr
20 Pp	2.2	16.8	9.6	59.4	11.5	tr	0.5
21 Pp	2.4	16.3	8.0	62.0	9.2	1.2	0.9
22 Pp	2.6	16.8	8.5	58.4	10.1	2.4	1.2
23 Pp	2.5	17.0	9.7	58.6	10.3	1.9	tr
24 Pp	2.7	18.4	9.1	58.0	9.4	1.8	0.6
25 Pp	2.6	17.1	9.8	58.3	10.7	0.9	0.6
26 Pp	1.7	17.0	8.9	60.3	12.8	1.3	tr
27 Pp	2.1	17.1	7.3	60.6	10.7	1.2	1.0
28 Pp	2.6	16.0	9.2	60.6	10.4	0.6	0.6
29 Pp	2.2	14.3	8.5	61.1	10.7	1.9	1.3
var. Peruviana (*M*)	2.27a	16.73a	9.00b	59.35a	11.04a	1.19a	0.59a
SD ($n = 15$)	±0.42	±1.03	±0.84	±1.79	±1.40	±0.63	±0.39

[a] Chol, cholesterol; Camp., campesterol; Stig, stigmasterol; Sit., β-sitosterol; Δ^5-aven, Δ^5-avenasterol; Δ^7-stig, Δ^7-stigmasterol; Δ^7-aven, Δ^7-avenasterol; tr, trace values less than 0.5. [b] Means followed by the same letter within each column are not significantly different at $P = 0.05$.

known concentrations of the standards. Iodine values were calculated from fatty acid percentages (Hashim et al., 1993) using the formula (% oleic × 0.8601) + (% linoleic × 1.7321) + (% eicosenoic × 0.7854).

Sterol Composition. Sterols of the unsaponifiable matter from 5 g of oil (after saponification with alcoholic 1 N potassium hydroxide) were purified by preparative thin-layer chromatography (TLC). TLC was performed on silica gel 60 G (20 × 20 cm, 0.5 mm layer thickness) plates using chlroroform–diethyl ether (9:1 v/v) as the developing solvent. The approximately relative R_f values of the 4-demethylsterols fraction was 0.27. The unsaponifiable matter was dissolved in chloroform (5%) and 150 μL was deposited as a streak of 15 cm length on the plate. Cholesterol, used as standard, was spotted on the left hand and right hand sides of the plate. The corresponding band of 4-demethylsterols was scraped off the plate and extracted with chloroform (Gaydou et al., 1983). Purified sterols were analyzed on a Shimadzu GC-R1A gas chromatograph equipped with FID. Shimadzu CBP1 capillary column (25 m × 0.25 mm i.d.) was used. Column temperature was programmed from 200 to 300 °C (4 °C/min). Injector temperature was 320 °C. The carrier (nitrogen) had a flow rate of 1 mL/min. Standard sterols (Sigma) were run in order to use retention times in identifying sample peaks. Sterol levels were estimated on the basis of peak areas of known concentrations of the standards.

Statistical Analysis. All analysis for each cultivars were done in triplicate. Significant differences among mean values from varieties of peanut were evaluated using a *t*-test.

RESULTS AND DISCUSSION

Oil, protein, and ash contents are listed in Table 2. These results were similar to peanut cultivars reported by Ahmed and Young (1982). The iodine value was higher in all samples. The variation of iodine values and oleic to linoleic ratios (Table 3) could be due to differences in climatic conditions, soil moisture and air temperature during maturation and temperatures during curing of peanut seed (Worthington and Hammons, 1971; Holaday and Pearson, 1974). The cultivars of the variety Hypogaea exhibited lower iodine value means than the other varieties (Fastigiata, Aequatoriana, and Peruviana). Furthermore, the variety Hypogaea showed lower protein level means. These results were significantly differents. The statistical analysis among varieties of peanut was done omitting the variety Aequatoriana, because the mean values of this variety were obtained from two cultivars.

Palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), arachidic (20:0), eicosenoic (20:1), behenic (22:0), and lignoceric (24:0) acids were detected (Table 3).

Significant differences were found within fatty acids among varieties of peanut (Table 3). Iodine value and oleic to linoleic ratio (O/L) are both indicators of oil stability and shelf life (Ahmed and Young, 1982; Branch et al., 1990). Traditionally in the United States, runner

market types have been predominantly utilized for the peanut butter trade, and oil composition (specially O/L ratio) likewise plays an important role in the manufacturing of this end-use product. Higher O/L ratios and lower iodine values suggest better stability, longer shelf life, and quality of the oils (Branch et al., 1990; Bansal et al., 1993). The variety Hypogaea showed higher oleic acid content and oleic to linoleic ratio (O/L) means than the other varieties.

The peanut oil is unique among vegetable oils in that it contains long-chain saturated fatty acids (20–24 carbons) (Worthington and Hammons, 1977; Treadwell et al., 1983). The range of concentrations of these fatty acids was similar to the peanut cultivars previously published (Ahmed and Young, 1982; Treadwell et al., 1983).

The following 4-demethylsterols were detected (Table 4): cholesterol, campesterol, stigmasterol, β-sitosterol, Δ^5-avenasterol, Δ^7-stigmasterol, and Δ^7-avenasterol. These results were similar to the amounts found for peanut cultivar oils previously published by Padley et al. (1986). Significant difference was only found for stigmasterol mean of the variety Peruviana.

This study about chemical composition of *A. hypogaea* seeds from Peru contributes useful information to the genetic quality of germplasm bank materials. The variety Hypogaea was characterized for exhibiting lower protein level and iodine value, and higher O/L ratio. This variety could be a possible source of genotypes with major O/L ratio values in peanut breeding programs of Argentina.

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